

Analysis of the effectiveness of energy strategies

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Abstract. The article examines the effectiveness of national strategic energy planning within the context of countries' adaptation to the global energy transition. The authors study the national energy strategies of the world's 20 largest economies, with a particular focus on the technological aspects of adaptation to the global energy transition, and give analysis of their correspondence with the actual national performance.

1 Introduction

The global energy transition is a multifaceted change in energy systems, including greater use of renewable energy sources and a reduction in the consumption of traditional resources. This trend involves the transformation of the energy system and inevitably affects other areas of social and economic life. Adapting to new conditions and potential challenges, the state develops a package of measures to maintain the functioning of closely related energy and economic sectors, determines the directions of technological development and coordinates planned activities with supranational institutions or international standards. The energy policy of the state is reflected in national energy strategies, which contain the goals and objectives of technological development of the state for a certain period, as well as priorities and mechanisms for implementing the national strategy. The purpose of this paper is to determine the effectiveness of national strategic planning of states to adapt to the global energy transition at the current stage. For this purpose, the article will analyze the national strategies of the largest economies of the world with a focus on trends in technological adaptation, as well as carry out their correlation analysis with the applicable indicators of actual technological readiness of countries. Based on the results of the analysis, the authors intend to provide a typology of the analyzed countries by the level of efficiency of their current national strategic planning in the field of adaptation to the global energy transition, and to determine Russia's place in this typology.

2 Methodology

Within the study, the authors conducted content analysis of national energy strategies of 20 states with the largest GDP at PPP as of 2021. The authors identified major trends of global technological development in the context of adaptation to the global energy transition and rated the countries according to the representation of those trends in their official energy

strategies. Secondly, the authors rated the countries according to their actual readiness to the global energy transition. Finally, the authors divided the analyzed states into groups according to the correspondence between the content of their national strategies and the level of their actual technological readiness for the global energy transition at the current stage.

3 Results

The energy program documents of the states define guidelines both in the field of energy policy and, indirectly, in the field of adaptation to climate change, social and economic development, etc. Since most energy strategies are not legally binding in and of themselves, various normative acts are adopted to implement them. It is worth noting that in addition to a single document containing the conceptual basis of the country's energy policy and key planning indicators, many countries have adopted a number of strategic planning documents, each of which addresses a different aspect of national energy policy.

In this study, the authors studied the energy strategies of 20 states. The parameters for the selection of these states were their GDP indicators at PPP 2021 as calculated by the International Monetary Fund [27].

Table 1. Countries selected for analysis (top 20 countries by GDP at PPP, 2021).

№	Country	GDP at PPP, \$ billion
1	China	27206
2	USA	22996
3	India	10194
4	Japan	5607
5	Germany	4888
6	Russia	4494
7	Indonesia	3566
8	Brazil	3436
9	UK	3403
10	France	3359
11	Turkey	2954
12	Italy	2735
13	Mexico	2669
14	Republic of Korea	2517
15	Canada	2025
16	Spain	1983
17	Saudi Arabia	1751
18	Egypt	1456

Continuation of Table 1.

№	Country	GDP at PPP, \$ billion
19	Australia	1454
20	Iran	1449

The authors identified the following trends of global technological development in the context of adaptation to the global energy transition, based on their mention in the analyzed national strategies:

- 1) Aiming to reduce CO2 emissions as much as possible (decarbonization);
- 2) Encouraging technical progress;
- 3) Electrification of transport;
- 4) Transition from non-renewable to renewable energy sources;
- 5) Encouraging investment in green energy;
- 6) Encouraging international cooperation;
- 7) Ensuring access to affordable and clean energy (SDG 7);
- 8) Digitalization;
- 9) Improving energy efficiency;
- 10) Training in new industries.

An analysis of the strategic documents of the 20 states based on the energy transition trends reflected in them is presented in Table 2.

Table 2. Analysis of the content of national strategies of states in the context of trends in the global energy transition.

Country	Seeking to reduce CO2 emissions as much as possible (decarbonization)	Training in new industries	Encouraging technical progress	Electrification of transport	Transition from non-renewable to renewable energy sources	Encouraging investment in green energy	Promoting international cooperation	Ensuring access to affordable and clean energy (SDG 7)	Digitalization	Improving energy efficiency	Rating
China	+	X	+	+	+	+	X	X	+	+	7/10
USA	+	+	+	+	+	+	+	X	X	+	8/10
India	+	+	+	+	+	+	+	+	+	+	10/10
Japan	+	X	+	+	+	+	+	X	+	+	8/10
Germany	+	+	+	+	+	+	+	+	+	+	10/10
Russia	+	X	+	X	+	X	+	+	+	+	7/10
Indonesia	+	X	+	+	+	+	X	+	X	+	7/10

Continuation of Table 2.

Country	Seeking to reduce CO2 emissions as much as possible (decarbonization)	Training in new industries	Encouraging technical progress	Electrification of transport	Transition from non-renewable to renewable energy sources	Encouraging investment in green energy	Promoting international cooperation	Ensuring access to affordable and clean energy (SDG 7)	Digitalization	Improving energy efficiency	Rating
Brazil	+	X	+	+	+	+	+	+	+	+	9/10
UK	+	+	+	+	+	+	+	+	+	+	10/10
France	+	+	+	+	+	+	+	+	X	+	9/10
Turkey	+	X	+	X	+	+	X	X	X	+	5/10
Italy	+	+	+	+	+	+	+	+	+	+	10/10
Mexico	+	+	+	+	+	+	X	+	X	+	8/10
Republic of Korea	+	+	+	+	+	+	X	X	+	+	8/10
Canada	+	+	+	+	+	+	+	+	X	+	9/10
Spain	+	+	+	+	+	+	X	+	+	+	9/10
Saudi Arabia	X	X	X	X	+	+	X	X	X	X	2/10
Egypt	+	+	+	+	+	+	+	+	+	+	10/10
Australia	+	+	+	X	+	X	+	+	+	+	8/10
Iran	X	X	X	X	+	X	X	X	X	+	2/10

Depending on the quantitative ratio of the trends mentioned in the documents, four groups of countries were identified:

1) Germany, Brazil, Great Britain, France, Italy, Canada, Spain, India, Egypt (the strategies reflect 9-10 trends out of 10 identified)

2) USA, Japan, Mexico, Republic of Korea, Australia (the strategies reflect 8 trends out of 10 identified)

- 3) China, Russia, Indonesia, Turkey (strategies reflect 5 to 7 trends out of 10 identified)
- 4) Saudi Arabia, Iran (the strategies reflect 2 trends out of 10 identified, political regulation in this area is poorly developed).

4 Analysis of technology readiness indices

The Energy Transition Index and the World Energy Trilemma Index were used to provide a qualitative assessment of countries' readiness for energy transition. The Energy Transition Index demonstrates the efficiency and readiness of the energy systems of different countries to "transition" and contains two sub-indices: System Performance and Transition Readiness. The World Energy Trilemma Index is an integral indicator of the effectiveness of national energy policies, containing three main dimensions: energy security, fair access to energy, environmental sustainability. It ranks countries by measuring their effectiveness in achieving a sustainable mix of policies, and the Balance grade emphasizes how well a country copes with the trade-offs within the energy trilemma [Khan et al., 2022]. Each of the three dimensions has its own grade: A is the highest score, while D is the lowest [28, 29].

To conduct a comparative analysis, the authors took into account the performance of selected countries in the Energy Transition Index and the World Energy Trilemma Index. To obtain the average of the two baseline indices, the authors calculated their arithmetic average. Based on the analyzed data, a table was compiled and the following four groups of countries were identified (Group 1 - the countries with the highest indicators, Group 4 - the countries with the lowest results):

- 1) Group 1 - Germany, UK, France, Canada (arithmetic mean ≥ 74)
- 2) Group 2 - USA, Japan, Brazil, Italy, Republic of Korea, Spain, Australia ($67 < \text{arithmetic mean} < 74$)
- 3) Group 3 - China, Russia, Turkey, Mexico, Saudi Arabia ($60 < \text{arithmetic mean} < 67$)
- 4) Group 4 - India, Indonesia, Egypt, Iran (arithmetic mean < 60)

Table 3. Assessment of the level of technological readiness of states for the global energy transition at the current stage.

№	Country	Energy Transition Index	World Energy Trilemma Index	Rating
1	China	57	65.3	61.15
2	USA	67	78.5	72.75
3	India	53	53.6	53.3
4	Japan	64	75.4	69.7
5	Germany	68	80.6	74.3
6	Russia	56	69.6	62.8
7	Indonesia	56	59.7	57.85
8	Brazil	66	68.8	67.4
9	UK	72	82.4	77.2
10	France	71	81.1	76.05

Continuation of Table 3.

№	Country	Energy Transition Index	World Energy Trilemma Index	Rating
11	Turkey	58	64.1	61.05
12	Italy	66	74.8	70.4
13	Mexico	62	63.1	62.55
14	Republic of Korea	61	73.6	67.3
15	Canada	67	82.3	74.65
16	Spain	68	77.9	72.95
17	Saudi Arabia	54	68.3	61.15
18	Egypt	55	60.8	57.9
19	Australia	65	77.1	71.05
20	Iran	50	60.1	55.05

As part of determining the correlation between the content of the analyzed national energy strategies of states and technological adaptation to the global energy transition with the obtained ratings of the actual technological readiness of countries for the global energy transition, the authors divided the analyzed states into 4 groups (Table 4).

Table 4. Grouping of countries by correspondence between the content of their national strategies and the level of actual technological readiness for the global energy transition at the current stage.

	Criterion - reflection of energy transition trends in the national strategy	Criterion - indicator of technological readiness at the current stage
Group 1	Germany, Great Britain, France, Canada, Brazil, Italy, Spain, India, Egypt	Germany, Great Britain, France, Canada
Group 2	USA, Japan, Mexico, Republic of Korea, Australia	USA, Japan, Republic of Korea, Australia, Brazil, Italy, Spain
Group 3	China, Russia, Turkey, Indonesia	China, Russia, Turkey, Mexico, Saudi Arabia
Group 4	Saudi Arabia, Iran	Iran, India, Indonesia, Egypt

5 Discussion

The results of the analysis allow to draw the following conclusions:

1. The two main trends of technological adaptation to the global energy transition, which are most widely reflected in the national energy strategies of most of the countries analyzed, are the desire to maximize the reduction of greenhouse gas emissions and increase energy efficiency. At the same time, all 10 identified trends are closely linked to technological

development and often depend on the implementation of tasks in the field of technological adaptation to the global energy transition and energy transformation in general.

2. The leading countries whose strategic planning corresponds to the level of actual technological adaptation to the trends of the global energy transition are Germany, Great Britain and France. It should be noted that the countries in this group are the key importers of energy resources. The analysis shows that the factor of the country's position in the world energy policy acts as a key driver of its real adaptation to the global energy transition, the actual adoption of measures to implement the goals set at the level of national strategic planning. Separately, it should be noted that Group 1 includes Canada, which is a major exporter of energy resources, which can also be explained by the political course of the country's leadership, as well as the high degree of integration of Canada in international initiatives of the G7 countries.

3. The largest economies paying the least attention to actual adaptation to the global energy transition include Iran, Saudi Arabia, India, Indonesia, and Egypt. This observation again emphasizes the importance of the position of countries in global energy policy in the context of actual adaptation (low levels are shown by energy-exporting countries; countries isolated from the political processes of the G7 and G20 groups; developing economies dependent on the use of traditional energy sources to ensure the dynamics of economic growth).

4. It is noteworthy that while the strategic documents of Saudi Arabia and Iran reflect the intention to take action to adapt to no more than two trends in the global energy transition, India and Egypt have fallen into Group 1 for the level of national strategic planning in this area. These countries are developing economies that are closely integrated in their economic activities with Group 1 and 2 countries. Further development of the actual adaptation of these countries to the energy transition can follow two scenarios: increasing the alignment of planned and actual indicators, or maintaining the current distribution. This variation is related to what explains the gap observed at the current stage: the lack of economic capacity for rapid restructuring or the formal and declarative nature of strategic planning.

5. Russia, as well as China and Turkey, are in Group 3 in terms of both their national strategic planning and the level of actual adaptation of their energy sector to the energy transition. Given that these countries are large emerging economies, the correspondence between national strategic planning and the actual measures taken in this area should be noted. However, unlike Russia, China and Turkey do not emphasize the importance of the international agenda in their national strategies and do not view the task of expanding international cooperation as a key priority in the context of the global energy transition. It should be noted that all Group 3 countries are less integrated into international and supranational initiatives to adapt to the global energy transition, and are more focused on national (rather than global) interests in strategic planning.

6 Conclusion

The most efficient way for a state to adapt to trends in global technological development and the energy transition is to harmonize strategic documents with available resources and its short- and long-term goals. In this article, the authors conducted a comprehensive review of the national strategies of the 20 largest economies, identified 10 key trends in the technological adaptation of states to the global energy transition, and compared the goals stated in the strategic documents of these states and the actual level of their adaptation at the current stage. The analysis showed that a number of countries are characterized by a significant gap between the goals and priorities set at the level of state strategic planning in the field of global energy transition, and the actual readiness of the countries at the current stage. It can be seen that such factors as the position of the country in international energy policy, the level of economic development of the state and the degree of its involvement in

international and supranational initiatives and programs in the relevant field are key both in the formation of national strategy and in its implementation.

The position of countries in the typology of countries developed by the authors in terms of the gap between the goals and priorities set at the level of state strategic planning in the field of global energy transition, and the actual readiness of countries at the current stage, may dynamically change. As part of further research, the authors intend to conduct a scenario analysis to predict such changes, their impact on international energy relations and assess the risks associated with them in order to form recommendations for choosing the optimal strategy for adapting to the global energy transition for the Russian economy.

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